Swine Feed and Ingredient Sampling and Analysis

Introduction

Preparing high quality swine diets is a complex process that involves several important components. Those components include ingredient procurement, diet formulation, feed manufacturing and delivery of the final diet. Careful attention must be given to the quality of the ingredients used to manufacture swine diets. The quality of the final diet also needs to be checked to ensure it is consistent with that of the original formula specifications or product description. Otherwise, optimal pig performance and economic outcomes may not be achieved. To ensure this consistency, a quality assurance program that involves product specification sheets, proper feed and ingredient sampling, analytical procedures and interpretation of laboratory results should be implemented.

Objectives

- Provide the basis for conducting feed and ingredient analyses
- Describe proper feed and ingredient sampling procedures
- Explain how to utilize a laboratory
- Outline how to interpret laboratory results

Basis for feed and ingredient analyses

Surveys show feed quality problems exist in the pork industry. For example, the crude protein, calcium and phosphorus concentrations of on-farm mixed swine feeds sometimes do not match that required for optimum performance and profitability [1, 2]. Moreover, variability exists in the nutrient content of common swine feed ingredients, like corn and soybean meal [3] and dried distillers grain with solubles (DDGS) [4]. Individual ingredients can vary widely in nutrient composition because of the variation in variety, storage conditions, climate, soil moisture, agronomic differences and manufacturing practices. Therefore, published nutrient profiles of ingredients (for example, those listed in PIG factsheet #07-07-09, Composition and Usage Rate of Feed Ingredients for Swine Diets) should be used as a guide in formulating diets.

The cost of feed and ingredient analyses will generally range from $0.25 to $3.00 per ton of finished feed [5, 6]. The largest contributor to these costs involves the use of laboratories to perform nutrient analyses. The following recommendations will help producers best allocate time and money for feed and ingredient analyses.

Who should conduct analyses?

Individuals who derive a significant portion of their income from pork production and strive to remain competitive should analyze feed and ingredients. The effort needed for analysis depends on how finished feed is obtained.
With commercial complete feed (a feed made according to the manufacturer’s specifications), there is limited need to spend a great deal of time and money testing. Most feed manufacturers rigorously analyze ingredients and finished feed and state regulatory officials check complete feeds at random for label compliance. However, it is a good idea to take a sample of each load, label and freeze it until those animals are marketed just in case a problem arises. Also, it is prudent to run a proximate analysis on random loads of feed and ingredients throughout the year and share the results with suppliers to let them know you are monitoring quality.

If feed is made on the farm or is custom mixed (according to producer specifications), a more extensive feed analysis program is necessary. Many custom mixed feeds are not checked by regulatory officials and the custom mixer may not have an adequate feed quality assurance program. Producers have total responsibility for feed made on their farm.

Producers who use by-products, such as DDGS, wheat midds, dried bakery products, etc. should design a schedule to test these ingredients. In general, by-products are more variable in nutrient content than grains. To ensure proper diet formulation, a nutrient analysis should be conducted on all by-products used in swine diets. The extent that by-products should be tested depends on where they are sourced. Buying from a reputable source with consistent product quality, strict quality assurance programs and their own nutrient specifications based on in-house testing results should warrant the least amount of testing. More details on procuring ingredients are found in the PIG Factsheet 07-06-08 (Purchasing High Quality Ingredients for Swine Diets).

**What analyses should be performed?**

Generally, routine analyses for vitamins, trace minerals (zinc, iron, etc.), amino acids other than lysine, and medications are not necessary. Those analyses are costly and less accurate than tests for other feed components. Money is better spent monitoring major feed components like protein, lysine, calcium, and phosphorus; consider mycotoxin analyses when utilizing weather-stressed feedstuffs, storage problems are suspected or certain abnormalities are observed in animals. See the PIG Factsheet # 07-06-07 (Utilization of Weather-Stressed Feedstuffs in Swine Diets) for further details on mycotoxins. The final decision on which analyses to perform depends on the ingredient and how the results will be incorporated either in the purchasing or formulation process. If the results are intended for diet formulation, a more thorough analysis, for example for several essential amino acids rather than just lysine, is usually necessary. Table 1 lists suggested minimum analyses for feeds and ingredients.

**Table 1. Suggested minimum analyses for finished feeds and selected ingredients.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Suggested analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feeds</strong></td>
<td>Moisture, crude protein, lysine (if protein is low), fat (in fat-added diets), calcium, phosphorus</td>
</tr>
<tr>
<td><strong>Ingredients</strong></td>
<td></td>
</tr>
<tr>
<td>Grain(^a)</td>
<td>Moisture, crude protein, lysine (if protein is very low), test weight, particle size</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>Moisture, crude protein, calcium</td>
</tr>
<tr>
<td>By-products, e.g., DDGS(^b)</td>
<td>Moisture, crude protein, lysine, fat, fiber</td>
</tr>
<tr>
<td>Fats/oils</td>
<td>Moisture, impurities, unsaponifiables (MIU), total and free fatty acids, peroxide value</td>
</tr>
<tr>
<td>Custom trace mineral and vitamin premixes and base mixes</td>
<td>Biotin or choline (sow diets only), vitamin E, phosphorus, zinc, crude protein if crystalline amino acids added</td>
</tr>
</tbody>
</table>

\(^a\)Consider a mycotoxin analysis or screen when utilizing weather-stressed ingredients, storage problems are suspected or certain abnormalities are observed in animals.

\(^b\)Distillers dried grains with solubles.
Analysis schedule

The best schedule for analyzing feed and ingredients for a given operation will depend on several factors. The amount of feed purchased or manufactured, supplier variability, and time available for sampling, sample preparation, and review of analytical procedures are important considerations in designing a schedule. Producers should develop a schedule and process that can be accomplished each week. Analytical results should be both timely and relevant in order to identify problems associated with feed quality. Consider analyzing feed and ingredients more often if quality problems are discovered. If feed is custom mixed, inquire about the manufacturer’s quality assurance program and adjust the schedule accordingly. Producers who purchase commercial feed should have the feed tested a minimum of once a month [7]. Analyze diets less frequently if test results match expectations. Ingredient analysis schedules should be set up based on the amount of ingredient received rather than on a time basis.

The risk of not producing the quality of feed intended is greatest with low inclusion base mix or premix-based diets mixed on the farm, so monitor diets made from base mixes or premixes more frequently. Major feed quality problems can occur easily when low inclusion products like premixes are used by people who are not experienced feed manufacturers.

By analyzing a combination of feed and ingredients, producers can quickly spot a wide range of possible feed quality problems. Also, it is easier to solve a quality problem in feed if individual ingredients have been analyzed.

The appropriate testing schedule for a particular operation should be designed in consultation with individuals familiar with the operation’s nutrition and feed manufacturing processes.

Laboratory services and selection guidelines

Several commercial laboratories, and some feed suppliers, universities and state departments of agriculture analyze feed and ingredients. Contact laboratories before submitting feed samples to find out the types of analyses available, how much each analysis costs, what sample size the lab prefers, and how long it will be before results are available. If a base mix or premix is to be analyzed, alert the laboratory of the expected concentration of the nutrients being checked. Some laboratories may not be equipped to accurately measure nutrients at concentrations normally found in base mixes or premixes [5].

Laboratory fees are variable. One reason for the difference is that some laboratories perform analyses in duplicate; they analyze a portion of a sample twice and report the average. Producers can be more confident in test results when the tests are duplicated, so use a laboratory with that policy when accuracy is of utmost importance, such as settlement of claims.

Sampling

Poor sampling technique will result in inaccurate and misleading test results. Sampling will be most accurate if the proper tools are used. Common tools used to sample dry materials include a bag trier (Figure 1), grain probe (Figure 2), and a Pelican sampler (Figure 3) or a clean, one-pound can. To sample from bags, use a 1 inch diameter double tube without compartments (a trier). The slot should be about ¾ inch in width. To sample bulk materials use a stainless steel, aluminum or brass grain probe, 1 3/8 inches in diameter and 60 to 72 inches long without compartments. Use a Pelican sampler or can to sample materials from an unloading or transferring stream. Pelican samplers consist of a container about 18 inches long, 2 inches wide and 6 inches deep attached to a handle. Pass the Pelican sampler or can across the width of a free-falling stream to obtain an accurate sample [5].
Below are guidelines for proper sampling of feed and ingredients. In each case, collect the samples in a clean 5 gallon bucket or similar container in preparation for sample reduction.

**Feeds in feeders:** Sampling from feeders may give the best assessment of the overall feed preparation program (mixing and handling procedure, ingredient quality, etc.). If there are 10 or fewer feeders present, sample all feeders; if ≥ 11 feeders are present, sample 10 randomly selected feeders. A grain probe works well to sample from feeders.

**Bulk feeds:** Request a feed sample from the supplier as the truck is loaded for each type of feed delivered to the farm [7].

**Bulk ingredients:** Cut the stream with a Pelican sampler or one-pound can at least 10 times at equal intervals during the delivery of the stream [5, 8] or before unloading, probe the truck at 4 to 6 evenly spaced locations to represent the entire load of ingredients [7].

**Bagged ingredients:** Lay each bag horizontally and remove the core sample diagonally from end to end. If 10 or fewer bags are present in the lot, sample all bags; from a lot ≥ 11 bags, sample 10 randomly selected bags [5, 8]. Samples from each bag should weigh about 0.5 lb [5].

**Materials for mycotoxin analyses:** The greatest variability or source of error in mycotoxin testing originates from sampling [9]. Therefore when testing grain or feed for mycotoxins, collect a 3 (for a truck load) to 11-lb (for a barge load) sample for analysis. A larger sample increases the chances of finding mycotoxins, especially in a large quantity of material [8, 10].

Producers who buy soybean meal and want to file a claim for possible quality problems (low protein, high moisture and fiber) should request an official NOPA (National Oilseed Processors Association) sample (taken by the processor and available upon request), instead of a sample collected by the producer. Even though testing a sample the producer collects identifies problems no one may have been aware of, it is not recognized as official under current soybean meal trading rules.

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**Sample reduction and preparation for analysis**

In many cases, the composite sample of a feed or ingredient will be larger than that needed for laboratory analysis and duplicate samples. Therefore, a systematic procedure for reducing the composite sample to a suitable size is important. Quartering is a classic manual method for dry sample reduction (Figure 4).

1. Thoroughly mix the composite sample.
2. Spread the composite sample out on a clean flat surface to form an even layer.
3. Divide into equal quarters.
4. Take two opposite quarters, mix and repeat if necessary to obtain two, 1 to 1.5 lb samples.
The quartering procedure is not practical for large feed manufacturers due to large sample size and number of samples. Therefore, mechanical methods of sample reduction such as a riffler (Figure 5) are available [5]. The feed or ingredient sample is poured into the riffler; the sample flows down a series of two chutes that discharge alternately in opposite directions into separate pans.

Seal each sample in individual, clearly marked and dated containers. Heavy plastic bags, plastic containers with lids, and wide mouth jars are excellent for storing samples for future nutrient analyses. Submit one sample to the laboratory and keep the other in the freezer until the analysis is complete [5, 8]. Materials collected for mycotoxin analysis should be sent to the lab in either a paper or cloth sack. Using plastic bags or metal cans may cause mold growth to occur in transit. [8, 10].

Label each sample clearly and completely with a permanent marker. Include date of sampling, date of delivery or manufacture, feed/ingredient type, who sampled, and any other pertinent information to allow for easy identification of the feed at a later date.

Interpreting laboratory results

In the event that laboratory results do not match an intended nutrient concentration or guarantee, remember that does not necessarily mean that the feed or ingredient is inferior. There are errors associated with sampling and laboratory analyses that at best can only be minimized. Such errors can cause differences in nutrient levels between what the laboratory reports and expectations. To reduce errors due to sampling, follow the sampling procedures described earlier [5].

The Association of American Feed Control Officials (AAFCO) establishes guidelines for analytical variation associated with the analysis of the nutrient content of feeds or ingredients (Table 2). These are designed to serve as a reference point for determining acceptability of feeds and ingredients based on laboratory results [11].

Generally there is no need for concern as long as analyzed nutrient values are not greatly different from the expected values. For complete feeds the expected nutrient values represent the calculated nutrient content of the diet. Therefore, comparing analyzed values to the calculated nutrient content of the diet is an essential step in understanding laboratory results.

Calculate the nutrient content (phosphorus, for example) of a feed from the diet formula, appropriate feed labels, and nutrient contents of ingredients. The accuracy of the calculations will improve by using the analyzed nutrient content of the ingredients in the diet if those are available. It will be necessary to use “published values” for some nutrients to finish the calculations because actual test results may not be available. A good source of expected nutrient contents for many ingredients is PIG factsheet #07-07-09, Composition and Usage Rate of Feed Ingredients for Swine Diets.
When reviewing laboratory results, use the “as-fed,” “as-is,” or “as-received” values, not the 100 % dry-basis values.

How much difference can there be between calculated and analyzed values before concluding there is a feed quality problem? The expected amount of variation associated with laboratory analyses for various items is shown in Table 2. Using the calculated or expected nutrient content of a diet or other manufactured products, a normal range of values can be calculated.

For example, assume the calculated phosphorus content of a diet is 0.60%. The range of acceptable phosphorus levels is between 0.52 and 0.68%. Using the analytical variation formula for phosphorus from Table 2, the expected level of variation in phosphorus concentration is 13% (3/0.60 + 8). Thus, analyzed phosphorus can vary by 0.08% units (0.60% x 0.13) or between 0.68% (0.60% + 0.08% units) and 0.52% (0.60% - 0.08% units).

If analyzed values for the diet fall within the normal range (between 0.52 and 0.68% in the example), no further action is necessary. However, if the level of all or any one of the nutrients fall outside the normal range and proper sampling procedures were used, submit a portion of the retained sample to the same laboratory for a repeat analysis. If the results from the second analysis also fall outside the normal range, a feed quality problem may exist. It should also be noted that if the concentration of a nutrient is consistently below or above the expected value there is a problem within the feed manufacturing process. Problems could be the result of a poor formula, improper mixing and handling procedures, a forgotten ingredient, or nutrient variation in ingredients.

Refer to PIG Factsheet # 07-06-07 (Utilization of Weather-Stressed Feedstuffs in Swine Diets) for guidelines on interpreting results of mycotoxin analyses.

<table>
<thead>
<tr>
<th>Determination</th>
<th>Methoda</th>
<th>AV%c,d</th>
<th>Concentration range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>954.01, 976.05, 976.06, 984.13</td>
<td>(20/x + 2)</td>
<td>10 to 85%</td>
</tr>
<tr>
<td>Lysine</td>
<td>975.44</td>
<td>20</td>
<td>0.5 to 4%</td>
</tr>
<tr>
<td>Fat</td>
<td>920.39, 954.02</td>
<td>10</td>
<td>3 to 20%</td>
</tr>
<tr>
<td>Fiber</td>
<td>962.09</td>
<td>(30/x + 6)</td>
<td>2 to 30%</td>
</tr>
<tr>
<td>Calcium</td>
<td>927.02, 968.08</td>
<td>(14/x + 6)</td>
<td>0.5 to 25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>10 to 25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>964.06, 965.17</td>
<td>(3/x + 8)</td>
<td>0.5 to 20%</td>
</tr>
<tr>
<td>Salt</td>
<td>969.10, 943.01</td>
<td>(7/x + 5), (15/x + 9)</td>
<td>0.5 to 14%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>0.03 to 1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30</td>
<td>&lt;0.03%</td>
</tr>
<tr>
<td>Copper</td>
<td>968.08</td>
<td>25</td>
<td>0.01 to 5%</td>
</tr>
<tr>
<td>Iron</td>
<td>968.08</td>
<td>30</td>
<td>0.01 to 17%</td>
</tr>
<tr>
<td>Manganese</td>
<td>968.08</td>
<td>20</td>
<td>0.002 to 6%</td>
</tr>
<tr>
<td>Zinc</td>
<td>968.08</td>
<td>(30/x + 6)</td>
<td>2 to 30%</td>
</tr>
<tr>
<td>Selenium</td>
<td>969.06</td>
<td>25</td>
<td>ppm</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>974.29</td>
<td>30</td>
<td>1200 to 218,000 IU/lb</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>952.20</td>
<td>45</td>
<td>1 to 1500 mg/lb</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>970.65, 940.33</td>
<td>30</td>
<td>3 to 500 mg/lb</td>
</tr>
<tr>
<td>Niacin</td>
<td>961.14, 944.13</td>
<td>25</td>
<td>4 to 190 mg/lb</td>
</tr>
<tr>
<td>Pantothenic Acid</td>
<td>945.74</td>
<td>25</td>
<td>1 to 1500 mg/lb</td>
</tr>
</tbody>
</table>

aAdapted from AAFCO, 2009.
cx  = % guarantee (example: for a 10% protein guarantee AV% = (20/10 + 2) = 4% of guarantee. This means the low AV is 4% of 10 or 0.4. Therefore, a sample below 9.6% is not acceptable.
dDenotes a true analytical variation and not a tolerance. Variations apply both above and below the guarantee and are equally correct.
Recourse

There should be an agreement in place prior to the purchase of any complete feed or ingredients like soybean meal and DDGS that addresses the compensation policy if nutrient concentrations fall outside the range of acceptable limits based on a specified analytical method. Product specification sheets should be developed for both feed and ingredient purchases and included as part of the agreement. Custom trading rules and law (for example, those for soybean from the National Oilseed Processors Association) afford producers remedies to problems associated with products that do not meet purchase specification. If product quality does not meet the agreed specification, contact the supplier. Other options for the buyer to resolve quality issues include rejection of the ingredient or feed, deficiency claims, negotiation, changing vendors, consideration of penalties, and product liability coverage [5]. Details concerning these options are available in the NPPC Feed Purchasing Manual (http://www.porkgateway.org).

Summary

Careful attention must be given to the quality of the ingredients used to manufacture swine diets as well as to that of the final diet in order for pigs to perform as expected. Errors in estimating the nutrient content of ingredients or mistakes during the feed manufacturing process can have profound effects on actual diet composition, pig performance and economic outcomes. Monitoring feed and ingredient quality using the guidelines outlined in this factsheet will help producers avoid potential problems with feed.

References


Frequently asked questions

Will having my ingredients analyzed by a laboratory aid in diet formulation?

Yes, because the nutrient content of ingredients will vary due to variation in species or variety, storage conditions, climate, soil moisture, agronomic differences and manufacturing practices. Therefore, “book” values of ingredient composition should be used as a guide in formulating diets.

Do I need to have my own quality control assurance for ingredients and complete feed?

Yes, because the nutrient content of the final feed does not always match expectations. Errors in ingredient procurement to feed delivery are possible and can be detected only through the implementation of a quality control program.

Is it important to use certain tools when taking a feed or ingredient sample?

Yes, because poor sampling technique will result in inaccurate and misleading test results. Common tools used to sample dry materials include a trier (for sampling bags), grain probe (for sampling bulk ingredients), and a Pelican sampler or a clean, one-pound can (for sampling materials from an unloading or transferring stream).
Who can analyze my sample?

Several commercial laboratories, and some feed suppliers, universities and state Departments of Agriculture analyze feed and ingredients. Contact laboratories before submitting feed samples to find out the types of analyses available, how much each analysis costs, what sample size the lab prefers, and how long it will be before results are available.

How should my samples be stored?

Seal each sample in individual, clearly marked and dated containers. Heavy plastic bags, plastic containers with lids and wide mouth jars are excellent for storing samples for future nutrient analyses. Submit one sample to the laboratory and keep the other in the freezer or cool dry area until the analysis is complete. Materials collected for mycotoxin analysis should be sent to the lab in either a paper or cloth sack. Using plastic bags or metal cans may cause mold growth to occur in transit.

Should finished feeds be tested for drugs or drug residues?

If there is any doubt about the residue status of your animals, it better to test rather than guess at their residue status. There is less need to monitor feed for drugs or drug residues if guidelines for processing medicated feed, referred to as current Good Manufacturing Practices (cGMPs) are followed. These guidelines are designed to prevent feed contamination of approved animal drugs and provide reasonable assurance that the medicated feed is manufactured accurately. See PIG Factsheet #07-04-03 (Swine Feed Processing and Manufacturing) for details. Also, following the guidelines outlined in the National Pork Board’s PQA Plus program will ensure the incidence of carcass drug resides is minimized.